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Control of the Purple Scale on Citrus With Parathion

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CONTENTS

	Page
Introduction	1
Experimental methods and materials	2
Experimental results	3
Safety precautions	6
Control with parathion and with oil emulsion	6
Effective spray concentrations	7
Compatible combinations	7
Importance of thorough coverage	7
Parathion residues	8
Parathion for clean-up	8
Effects on trees, foliage, and fruit	8
Comparative costs	9
Parathion in the spray program	9
Summary	10
Literature cited	10

INTRODUCTION

Control of the purple scale (*Lepidosaphes beckii* (Newm.)) has been a costly problem for citrus growers of the Southeastern States for almost a century. Since 1913 the growers, following the method developed by Yothers (*3*),[2] have used oil emulsions for control, but these materials have shown definite shortcomings. With heavy infestations, in droughts, or in cold weather they caused leaf drop; fruit sprayed late in the year remained sour; and as they could not be combined with the regular sulfur applications, spraying costs were high.

In 1947 parathion became available, and preliminary experiments were conducted to test its value for control of the citrus red mite (*Paratetranychus citri* (McG.)). In the first experiment Valencia orange trees were sprayed with 1 quart of 20-percent parathion emulsion concentrate to 100 gallons of water. In the second experiment the spray contained 6 pounds of 15-percent wettable parathion plus

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[1] R. E. Brungard, Bernard Knecht, Herrick B. Cook, and James L. Sligh assisted in the experiments reported in this paper.

[2] Italic numbers in parentheses refer to Literature Cited, p. 10.

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6 pounds of wettable sulfur per 100 gallons. The high concentrations of parathion did not control citrus red mites, and even caused a delayed build-up of these mites (Spencer and Osburn *2*), but there was very effective control of the purple scale (table 1, experiments 1 and 2). These results led to further experiments with parathion in combination sprays for control of the scale insects and mites of citrus. Information was sought on the minimum quantities required per 100 gallons of spray for adequate control, on its compatibility with fungicides and insecticides now in the spray schedule, on possible injurious residues on fruits and trees, on the number of applications necessary each year, and on the timing of the applications.

This circular gives the results of 15 grove experiments with parathion for control of the purple scale, and discusses utilization of this new material in the citrus spray program.

Experimental Methods and Materials

All the experiments were conducted on the east coast of Florida in commercial groves of standard varieties of oranges and grapefruit, by cooperative arrangements with the owners.[3] Some of the groves contained young trees in full bearing, and others were magnificent old groves. Uniformity of tree size was a prime consideration in the selection of each grove. Groves with missing trees, replants, or mixed varieties were avoided.

The experiments were arranged in randomized blocks (Spencer and Osburn *1*). Each block contained as many trees as there were spray treatments being compared. The positions of the treatments were assigned by chance in each block, so that tree-row variations could not influence the results from the different sprays. There were 10 blocks (or replications) in all experiments except one (table 1, no. 5), which had 5. In most of the experiments a standard oil-emulsion spray was included for comparison or there were check trees that received no scalicide but were included in the usual spray program for control of the citrus rust mite (*Phyllocoptruta oleivora* (Ashm.)) and diseases. As the work progressed most of the combination sprays contained parathion and wettable sulfur, and often copper fungicides and miticides were added, to determine their compatibility and the feasibility of obtaining simultaneous control of scale insects, mites, and diseases. The sulfur used was a 90-percent wettable formulation, and the basic copper sulfate contained 53 percent of copper; the emulsive oil contained 99.5 percent of oil; and the oil emulsion 90 percent.

To insure uniformity, one spray hand, trained and experienced by many years of such work, applied nearly all the sprays. He used a 200-gallon tank and a 3-cylinder pump driven by a separate gasoline engine, which delivered 35 gallons per minute when adjusted for a pressure of 400 pounds per square inch. A single lead of hose was equipped with an orchard spray gun that had a single nozzle containing a No. 6 ($6/64$-inch) or No. 7 ($7/64$-inch) disk. Leaves, fruits, twigs, and branches were covered thoroughly, in what growers call an inside and outside scale-control job.

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[3] The grower cooperators were F. E. Colburn, Walter Peterson, Norman G. Platts, W. F. Slade, and C. M. Stecher.

In experiments 1 to 7 and 15 the combination sprays were applied to Valencia orange trees; in experiments 11 and 12 the variety was Hamlin early orange; in 8 and 9 the sprays were applied to Temple oranges. Two varieties of grapefruit trees were included, Marsh seedless in experiment 10 and Ruby in experiments 13 and 14.

Parathion sprays were applied to citrus trees in every month of the year except September, December, and January. In some experiments two applications were made to the same trees in one year.

EXPERIMENTAL RESULTS

Several months after the last spraying samples of 20 mature leaves taken at chest height around each tree, or 200 per treatment, were examined under a microscope, and the living purple scales (except eggs) on half the upper surface and half the lower surface of each leaf were counted. The results are given in table 1.

TABLE 1.—*Control of the purple scale with parathion and with oil-emulsion sprays (E=emulsion; W=wettable powder)*

Insecticide formulation (quantity per 100 gal.)	Spray dates	Sampling date	Number of living scales per leaf	
			Before spraying	At sampling
Experiment 1				
Parathion 20% E 1 qt	June, Oct. 1947	Feb. 1948		0.08
Emulsive oil 1 gal	do	do		.59
Untreated		do		6.49
Experiment 2				
Parathion 15% W 6 lb. plus sulfur 6 lb.	June, Nov. 1947	do		.03
Sulfur 6 lb	do	do		13.87
Experiment 3				
Parathion 15% W 6 lb. plus sulfur 6 lb.	June, Nov. 1947 and Feb. 1948.	May 1948		.73
Sulfur 6 lb	do	do		14.71
Experiment 4				
Parathion 25% W 1 lb. plus sulfur 6 lb.	May 1948	Nov. 1948	14.71	3.04
Experiment 5				
Parathion 25% W:				
2 lb	June 1948	July 1948		.52
1 lb	do	do		.86
Untreated		do	4.75	17.92

See footnotes at end of table.

TABLE 1.—*Control of the purple scale with parathion and with oil-emulsion sprays (E=emulsion; W=wettable powder)*—Continued

Insecticide formulation (quantity per 100 gal.)	Spray dates	Sampling date	Number of living scales per leaf	
			Before spraying	At sampling
Experiment 6				
Emulsive oil 1¼ gal.	June 1948	Dec. 1948		0.74
Do	Nov. 1948	do		.13
Do	June, Nov. 1948	do		.07
Parathion 20% E 2½ pt	do	do		.03
Parathion 25% W 2 lb	do	do		.01
Untreated		do		1.50
Experiment 7				
Emulsive oil 1 gal	July 1949	Sept. 1949	1.17	.14
Parathion 15% W 2 lb. plus sulfur 5 lb.	do	do	.38	.01
Parathion 15% W 2 lb. plus sulfur 5 lb. plus Neotran[1] 40% W 2 lb.	do	do	2.71	0
Parathion 15% W 1 lb. plus sulfur 5 lb.	do	do	.41	0
Experiment 8				
Parathion 15% W 2 lb. plus sulfur 5 lb. plus basic copper sulfate 3 lb.	April 1949	May 1949	2.73	.66
Sulfur 5 lb. plus basic copper sulfate 3 lb.	do	do	2.73	2.73
Experiment 9				
Emulsive oil 1 gal	May 1949	Sept. 1949	2.73	.54
Parathion 25% W 1 lb. plus sulfur 6 lb.	do	do	2.73	.59
Experiment 10				
Parathion 15% W 2.4 lb. plus sulfur 5 lb. plus basic copper sulfate 3 lb.	April 1949	June 1949	5.50	1.30
Parathion 15% W 1.2 lb. plus sulfur 5 lb. plus basic copper sulfate 3 lb.	do	do	5.50	3.04
Experiment 11				
Oil E 1.4 gal	June 1949	May 1950		22.38
Do	Aug. 1949	do		14.23
Do	June, Aug. 1949	do		15.46
Parathion 15% W 2 lb. plus sulfur 5 lb.	June 1949	do		20.69
Do	Aug. 1949	do		11.73
Do	June, Aug. 1949	do		6.32
Untreated		do	2.62	27.34

See footnotes at end of table.

TABLE 1.—*Control of the purple scale with parathion and with oil-emulsion sprays (E=emulsion; W=wettable powder)*—Continued

Insecticide formulation (quantity per 100 gal.)	Spray dates	Sampling date	Number of living scales per leaf	
			Before spraying	At sampling
Experiment 12				
Oil E 1.4 gal	June 1950	Dec. 1950	22. 38	10. 57
Do	Aug. 1950	do	14. 23	5. 87
Do	June, Aug. 1950	do	15. 46	2. 82
Parathion 15% W 2 lb. plus sulfur 5 lb.	June 1950	do	20. 69	7. 20
Do	Aug. 1950	do	11. 73	2. 28
Do	June, Aug. 1950	do	6. 32	1. 99
Untreated		do	27. 32	18. 02
Experiment 13				
Parathion 15% W 1 lb. plus sulfur 5 lb. plus basic copper sulfate 3 lb.	Mar. 1950	July 1950		3. 57
Parathion 15% W 2 lb. plus sulfur 5 lb. plus basic copper sulfate 3 lb.	do	do		1. 56
Sulfur 5 lb. plus basic copper sulfate 3 lb.	do	do	7. 34	15. 62
Experiment 14 [2]				
Parathion 15% W:				
1 lb	Mar. 1950	Nov. 1950		20. 81
1 lb	July 1950	do		22. 42
1 lb	Mar., July 1950	do		9. 33
2 lb	Mar. 1950	do		13. 91
2 lb	July 1950	do		10. 65
Untreated		do	7. 34	25. 22
Experiment 15				
Emulsive oil 1 gal	July 1950 [3]	Feb. 1951	. 14	1. 28
Parathion 15% W 2 lb. plus sulfur 5 lb.	July, Nov. 1950	do	. 01	. 12
Parathion 15% W 2 lb. plus sulfur 5 lb. plus Neotran [1] 40% W 2 lb.	do	do	0	. 26
Parathion 15% W 1 lb. plus sulfur 5 lb.	do	do	0	. 22

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[1] A miticide containing 40% of bis(*p*-chlorophenoxy)methane.

[2] All trees in this experiment were sprayed in March with basic copper sulfate 3 lb. plus wettable sulfur 5 lb. per 100 gal. and in July all received 5 lb. of wettable sulfur per 100 gal.

[3] The first group of trees in this experiment received 5 lb. of wettable sulfur per 100 gal. in November 1950.

SAFETY PRECAUTIONS

Because parathion is a very poisonous chemical, special care was taken in handling it in these experiments. The driver, the mixer, and the spray hand were equipped with respirators that had suitable chemical cartridges as well as felt pads for filtering the air. The filter pads were changed daily, and the cartridges were replaced when they began to pass the odor of parathion. Wide-brimmed hats and long-sleeved shirts were worn. Clean clothing was worn each spray day. Soap and clean towels were carried in the sprayer cab, and operators washed face and hands each time the spray tank was taken back to the water point for refilling.

In adding 15- or 25-percent parathion wettable powder to the water, the mixer always stood on the windward side and poured the material in as gently as possible to avoid stirring up the concentrated dust and being covered with it. He mixed large amounts in a 5- or 8-gallon milk can or bucket of water, with a wooden paddle, before adding it to the water in the spray tank. In spraying the leeward side of the tree, the spray hand stood first on one side of the drift and then on the other side, to get thorough coverage of the tree and at the same time to avoid the heavy spray drift.

Tablets of atropine sulfate, the antidote, were always available in the spray and service trucks, but were never needed. Physicians in the district were furnished information on symptoms and the recommended treatment of cases. All personnel were briefed thoroughly on the proper use of parathion and on safety precautions, and on the danger of being careless with parathion. Cigarette smoking was permitted only at the water-refilling point, after the hands had been washed with soap and water.

The printed safety precautions on each package of parathion were helpful as an ever-present reminder that one should not get careless.

No symptoms of parathion poisoning were shown by any of the workers in these experiments. Even in the early work, when high concentrations were used, the precautions outlined were adequate. However, a single period of spraying seldom exceeded 3 days. The dangers would have been greater if the spray crew had operated continuously for a number of weeks. In such a case the safety precautions practiced would have had a more severe test.

It is clear, though, that careless workers should not be allowed to handle parathion.

CONTROL WITH PARATHION AND WITH OIL EMULSION

In seven experiments there were 16 direct comparisons of control of purple scales with parathion and with oil emulsion. In all but one, parathion sprays controlled purple scales better than oil-emulsion sprays, but the differences were slight and many of them were not significant on statistical analysis. In the single case where oil seemed to be better than parathion (experiment 9), the difference was only 0.05 scale per leaf at sampling time. It may be concluded that parathion controlled the purple scale at least as well as did the oil emulsion.

Effective Spray Concentrations

In the experiments in 1947 the sprays contained high concentrations of parathion, but each year thereafter the concentration was reduced to determine the minimum that would give satisfactory control. On Valencia orange and other trees with light infestations, single sprays containing 2 pounds of 15-percent wettable parathion per 100 gallons applied between early March and late August gave good control. Two sprays, early in the summer and in the fall, containing 1 pound of 15-percent wettable parathion per 100 gallons also gave excellent control. On grapefruit, Temple orange, and other varieties that receive copper and zinc sprays and develop heavy infestations, two applications in a year were better than single sprays, and 1 pound of 15-percent wettable parathion per 100 gallons each time was almost as good as twice that concentration.

In experiment 14, 1 pound of parathion per 100 gallons applied in March and July resulted in lower infestations at picking time than single applications of 2 pounds of parathion either in March or in July. However, these grapefruit trees had received winter nutritional sprays containing zinc and manganese and a post-bloom spray containing copper. Come-back of purple scales after the March sprays was rapid, and a heavy infestation developed. With such heavy infestations it might be better to use 1 pound of 15-percent parathion in the post-bloom spray in March and 2 pounds in the summer spray; or 1 pound could be used in the March spray, 1 pound in July, and 1 pound in the fall application of wettable sulfur.

Compatible Combinations

In 12 experiments wettable parathion was combined with wettable sulfur. This combination spray was safe for the trees and was effective. The wettable sulfur controlled the rust mites and the parathion the scale insects. Until this combination was available, separate sprays were necessary when heavy infestations of both pests were present, because sulfur and oil sprays combined are unsafe for trees and fruits. Use of the wettable sulfur plus parathion permits omission of the summer-oil spray, at a saving to the grower.

In four experiments wettable parathion was added to the post-bloom spray of wettable sulfur and neutral copper, the copper being a fungicide for the melanose disease. This combination was also satisfactory.

In experiments 7 and 15 the miticide Neotran was added to the wettable sulfur and wettable parathion, with good results. This combination is useful where there are heavy concurrent infestations of citrus red mites, citrus rust mites, and scale insects.

Importance of Thorough Coverage

In all except one experiment thorough coverage was obtained by use of adequate gallonage applied with a single hand gun by an experienced spray hand. In experiment 10 mature Marsh seedless grapefruit trees were sprayed with a tractor-drawn, power-take-off sprayer equipped with a multi-nozzle boom. Only 8⅓ gallons of spray per tree was delivered, which is about half the gallonage estimated for adequate coverage. The original infestation of 5.5 scales per leaf was reduced only to 1.3 scales with 2.4 pounds of 15-percent wettable parathion per 100 gallons, and to 3.04 scales with 1.2 pounds. Control was not so complete with this inadequate gallonage and poor coverage as in the other experiments. Spray coverage should be just as thorough and complete with parathion sprays as with the oil-emulsion sprays.

Parathion Residues

On January 4, 1949, 64 days after the last spraying, fruit samples were collected from the parathion-sprayed and the untreated trees in experiment 6 for determination of parathion residues.[4] After 2 months of weathering there was only 0.02 part per million of parathion on the outside skins of the fruit that had been sprayed with the suspension of wettable parathion and none on those sprayed with parathion emulsion. In the peels of the fruits sprayed with wettable parathion there was 0.70 part per million of parathion, and in those sprayed with parathion emulsion, 0.32 part per million. No parathion was detected in the juice of any of the samples. Other analyses have given similar results, and have shown that the parathion absorbed into the peel remains there for at least 4 months. From these analyses it appears that juice from oranges sprayed with parathion is safe for human consumption, but that peel products, such as orange-peel oil, marmalade, or byproduct used for cattle feed, might contain detectable amounts of parathion. Of these products it is believed that peel oil is the most likely to contain harmful concentrations.

Parathion for Clean-Up

Purple scale infestations may appear in the summer, fall, or early winter, especially on trees that have had residual sprays earlier or where summer sprays have been ineffective. In experiment 3 the second group of trees had no scalicide in 1947 or early in 1948. They were heavily infested by May, and were sprayed with parathion plus wettable sulfur, with good control. In other experiments not recorded in table 1, parathion was used successfully for clean-up of purple scales in September and in February. For these heavy, neglected infestations 2 pounds of 15-percent wettable parathion with wettable sulfur was used per 100 gallons, and particular attention was given to thorough coverage. Parathion provides an effective and safe material for fall and winter control of heavy infestations.

Effects on Trees, Foliage, and Fruit

Parathion caused no harm to the trees, foliage, or fruit at any time of the year. In fact its effect often appeared beneficial. In experiment 3 trees sprayed three times in a 2-year period had luxuriant foliage, very little deadwood, and exceptionally bright fruit, and they looked much better than trees in the same block that had received no parathion. Heavy infestations of the purple scale had developed in the untreated trees, many leaves had shed, some small wood was dying, and the fruits were covered with scales and sooty mold.

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[4] These analyses were made by chemists of the Division of Insecticide Investigations.

A beneficial effect of parathion sprays was also seen in experiment 1. Beginning in February and each month thereafter through May, fruit samples were taken from these Valencia trees, and the oranges were washed, graded, weighed, and tested for solids, acid, vitamins, juice content, color and taste.[5] The fruits from the trees sprayed with parathion were heavier, brighter in color, higher in solids-acid ratio, and rated higher in palatability than fruits from the unsprayed trees. Trees sprayed late in the year with oil were much inferior in quality to the parathion-sprayed or the unsprayed lots.

These beneficial effects were undoubtedly due in part to control of heavy insect infestations, but it is possible also that the parathion had a stimulating effect on the trees.

Comparative Costs

The comparative costs of oil emulsion and parathion sprays have to be considered by users. At current prices (May 1951) stock oil emulsion containing 90 percent of oil, sells for about 31 cents per gallon and 15-percent parathion wettable powder for about 55 cents. The cost of applying 100 gallons of spray varies considerably but may be set at an average of $1.35.

Parathion can be added to a regularly scheduled wettable-sulfur spray for rust mites, which have to be controlled with a separate spray if oil has been used for scale control. The use of parathion in combination with wettable sulfur will avoid the cost of a separate spray. Two pounds of 15-percent parathion per 100 gallons, added to the wettable-sulfur spray, will cost only $1.10 additional; 1 pound, only 55 cents. With this treatment control of purple scales will be cheaper than with a separate oil application, which would have to be followed in 3 or 4 weeks with a wettable-sulfur spray.

A separate spray of oil emulsion containing 1.25 percent of oil costs $1.78 and a separate spray containing 2 pounds of 15-percent parathion costs $2.45 per 100 gallons. If the concentration of parathion is only 1 pound, the cost is $1.90 per 100 gallons, still slightly more than that of the oil spray.

Parathion in the Spray Program

Parathion has given as good control of purple scales as oil emulsion. Because it can be added to regularly scheduled wettable-sulfur sprays or to sprays of neutral copper and wettable sulfur at any time of the year when purple scale infestations develop, the necessity of a separate oil-emulsion spray is avoided and the number of yearly sprayings is reduced by one. It will not displace oil completely in the spray program except for clean-up of infestations between July and February. In the post-bloom spray, copper to which oil has been added is cheaper to use where diseases, scale insects, and citrus red mites are prevalent and where there is no infestation of rust mites. When rust mites are present, a combination spray of neutral copper, wettable sulfur, parathion, and a miticide such as Neotran will control melanose, rust mites, purple scales, and citrus red mites. It is expensive, but is preferable to a copper-oil spray followed in 3 to 4 weeks with a spray of wettable sulfur.

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[5] These tests were made by Paul L. Harding and his testing panel at the Orlando, Fla., laboratory of the Bureau of Plant Industry, Soils, and Agricultural Engineering.

SUMMARY

Parathion sprays gave as good as or better control of the purple scale (*Lepidosaphes beckii* (Newm.)) than oil-emulsion sprays in 14 out of 15 comparisons in experiments on orange and grapefruit trees in Florida over a 4-year period. In one experiment where oil emulsion gave better control the difference was slight and nonsignificant.

For heavy infestations, particularly on grapefruit and Temple orange trees receiving copper and nutritional sprays, the minimum effective concentration was 2 pounds of 15-percent or 1 pound of 25-percent wettable parathion per 100 gallons of water. Two applications a year were sometimes necessary, especially if the first spraying was done early in the spring.

For light infestations 1 pound of 15-percent wettable parathion per 100 gallons was satisfactory if applied with thorough coverage. Two sprayings a year with this lower concentration gave better year-around control than a single spraying. Parathion emulsion concentrate gave control comparable to that from parathion wettable powder.

Parathion was found to be compatible with wettable sulfur, basic copper sulfate, and certain summer miticides, and so can be used in combination sprays. It thus has a distinct advantage over oil emulsion, which is incompatible with the routine sulfur sprays and must be applied separately. The elimination of one or more applications from the annual spray program would more than offset the higher cost of the parathion.

Parathion was used in spring, summer, fall, and winter months with no damage to grapefruit or orange trees or fruits. Fruits from trees sprayed with parathion were bright in color and high in external and internal quality. No external residues of parathion were detected at picking time, nor was any parathion found in the juice, but a minute quantity remained in the peels. Trees sprayed late in the year with oil were much inferior in quality to the parathion-sprayed or the unsprayed trees.

For control of heavy infestations late in the year, parathion was a satisfactory material. In parathion the growers now have an effective and versatile new insecticide for controlling the purple scale on citrus.

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